NOAA SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP)
PROJECT ANNUAL REPORT

PROJECT TITLE

Improved Water Resources Management in the Sahel-Sudan, a Case Study of Burkina Faso

INVESTIGATORS
(Research team and full contact information)

Paul Kirshen, Tufts University, Medford MA, Principal Investigator (paul.kirshen@tufts.edu)

M. Carla Roncoli, University of Georgia, Griffin GA, Co-Principal Investigator (croncoli@uga.edu)

Gerrit Hoogenboom, University of Georgia, Griffin, GA Co-Principal Investigator (gerrit@uga.edu)

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PROJECT YEARS JUNE 1, 2006 TO MAY 31, 2009

TIME PERIOD ADDRESSED BY REPORT *(e.g., August 2002-March 2003)*

MARCH 1, 2008 TO FEBRUARY 28, 2009

I. PRELIMINARY MATERIALS

A. Project Abstract *(Limit to one page*

The Sahel-Sudan climatic zone south of the Sahara Desert is characterized by a strong north-south gradient of seasonal (summer) rainfall varying from 100 mm annual rainfall in the extreme north to over 1000 mm in the extreme south. The region's rainfall is characterized by extreme seasonal and annual temporal and spatial variability. The major livelihood activity in Burkina Faso is rainfed cultivation of cereal crops with limited cultivation of rice, peanut, and cowpea. Cotton is the dominant export crop and is mostly grown in the southwest. Livestock management is an important complement to farm activities, especially in the Sahelian zone. There are several major rivers flowing through the region and many ephemeral streams flowing only during the wet season. Surface water resources are becoming more important to Burkina Faso as it tries to improve food security and water supplies, and increase energy production. There are at least four significant irrigation schemes; the Upper Comoe in the southwest, Sourou Valley in the northwest, and Bagre and Kompienga in the southeast. The overall **objective** of this project is to identify and test constraints and opportunities, both at the institutional level and at the community level, for utilizing seasonal climate forecasts to improve irrigation surface water management in Burkina Faso as an example of possible water management improvements in the Sahel-Sudan. Our proposed research is to conduct a pilot project to deliver streamflow forecasts and build an associated reservoir management decision support tool (DST) to improve irrigation water management in the case study area of the Upper Comoe River Basin. Stakeholders include the sugar cane company SOSUCO, the town of Banfora, and a farmer cooperative at Karfiguela, in addition to other downstream users (riparian farmers, pastoralists, and fishermen). They are served by multiple large reservoirs. The research includes

reviewing the state of the art of streamflow and rainfall forecasting for the area (rainfall is necessary because supplemental irrigation is used at some sites), conducting research on farmers' and dam operators' needs for forecasts and how to coordinate releases with downstream needs, designing with the users the objectives of a streamflow and rainfall forecasting system and reservoir management DST, building the forecasting system and DST, and testing with the users. The primary research will be carried out by the CFAR team from Tufts University and the University of Georgia. Collaborators in Burkina Faso include Direction Générales des Ressources en Eau (DGRE), Institute de l'Environnement et des Recherches Agricoles (INERA), and Direction de la Météorologie (DM).

B. Objective of Research Project *(Limit to one paragraph*

The overall objective of this project is to identify and test constraints and opportunities, both at the institutional level and at the community level, for utilizing seasonal climate forecasts to improve irrigation surface water management in Burkina Faso as an example of possible water management improvements in the Sahel-Sudan.

C. Approach (including methodological framework, models used, theory developed and tested, project monitoring and evaluation criteria) include a description of the key beneficiaries of the anticipated findings of this project (e.g., decision makers in a particular sector/level of government, researchers, private sector, science and resource management agencies) *(Limit to one page)*

Task 1: Reconnaissance of Comoé River. The U.S.-based team and its Burkina Faso partners will travel to the Comoé Basin to learn about the water management system, its operation, and stakeholder uses.

Task 2: Reviewing the State of the Art in Seasonal Rainfall and Streamflow Forecasting in the Region and Initial Prediction Tool Implementation and Evaluation. A review the state of art of seasonal rainfall and streamflow forecasting in the region will be completed at the onset of the project. The review will emphasize the probable needs of water resource management in the watershed. Needs may include forecasts of precipitation for the wet season, forecasts of streamflow for the year, and translation of these into ensemble traces of sub-seasonal rainfall and streamflow applying temporal and spatial downscaling techniques. Methods for updating the forecast information during the season will be explored.

Task 3: Reviewing and Assembling Hydrologic, Meteorological, and Hydraulic Data. An assessment of technical data needs for the DST will be conducted and the necessary data will be compiled in electronic formats by the Burkina Faso partners and provided to the U.S. based team that is building the DST.

Task 4: Identifying Stakeholders, Information Needs, Communication Flows, Potential Uses and Impacts of Forecast Information. A rapid stakeholder assessment will be conducted to identify stakeholders, decision making processes, and understand the social and institutional context. Further field research based on interviews with users and decision makers will capture the linkages between resource management decisions and potential impacts of the DST.

Task 5: Review of Environmental and Public Health Issues. A preliminary review of environmental and public health issues possibly related to the operation of the reservoirs and irrigation system will be conducted.

Task 6: Preliminary Design of Decision Support Tool. Using the results of the previous tasks, a preliminary version of the DST will be developed and discussed with stakeholders early in the research so that appropriate adjustments can be made in the DST design. Stakeholder feedback will also be elicited on the DST presentation format and communication mechanisms.

Task 7: Implementing the Pilot Project. Based on the results of Task 6, the DST will be built and tested by using hindcasting to show how the DST would have worked in past recent years. The DST will then be

implemented at the project site. The results of the hindcasting will show users how the DST would have worked in past recent years and help demonstrate the strengths and weaknesses of the DST. Training will be provided to the stakeholders and all project partners on how to use the tools. It is recognized that sustainable reservoir management requires adaptive learning and that this study will provide an opportunity for learning rather than a fixed formula for management. The U.S.-based team will provide remote technical support to the stakeholders and to Burkina Faso partner institutions in their use of the DST in the year following project completion. This will also provide evaluation of the tool.

Beneficiaries of the project will include both corporate and private farmers, the town of Banfora (its water supply comes from the reservoirs), and other stakeholders that utilize the water of the Upper Comoé River Basin. Host-country scientists will also benefit from capacity building and research opportunities. In addition, the results will guide similar efforts in West Africa, where due to unpredictable climate and increased pressure on water resources, more dams are being planned and constructed.

D. Description of any matching funds/activities used in this project *(Limit to one paragraph)*

The Tufts University graduate research assistant on the project was partially supported by John R. Freeman Fund from the Boston Society of Civil Engineers Section of the ASCE. In addition, some of the time and expenses of Moussa Sanon of INERA were devoted to this project while he was supported by a Fulbright at the University of Georgia from November 2006 to December 2007. In March 2009 Dr. Sanon also spent one month at the University of Georgia to collaborate on publications.

II. ACCOMPLISHMENTS

A. Brief discussion of project timeline and tasks accomplished. Include a discussion of data collected, models developed or augmented, fieldwork undertaken, or analysis and/or evaluation undertaken, workshops held, training or other capacity building activities implemented. *(This can be submitted in bullet form – limit to two pages)*

Results per task are below.

Task 1: Reconnaissance of Comoé River *(January 2007)*

The Tufts and UGA toured the basin with DM, INERA, and DGRE partners in early January 2007 and met with dam owners and water users.

Task 2: Reviewing the State of the Art in Seasonal Rainfall and Streamflow Forecasting in the Region and Initial Prediction Tool Implementation and Evaluation *(June 2007- June 2008).* In Fall 2007, a visit was made to the International Research Institute at Columbia University to discuss forecasting state of the art in the region. It was decided that the present tercile forecast for the total precipitation over the period July through September was the most realistic forecast to use for our research. Our tools, however, are being built to incorporate more advanced forecasts when they become available. Until they are, the tools will use climatology as forecasts for other periods of the year. Forecasts of runoff will be based upon rainfall-runoff models, assuming the resulting runoff has the same probability distribution as the rainfall.

Task 3: Reviewing and Assembling Hydrologic, Meteorological, and Hydraulic Data *(January 2007- April 2008).* During our initial field trip to the region in January 2007, much of the preliminary data were collected. During the field trips of January 2008 and January 2009, additional data were assembled.

Task 4: Identifying Stakeholders, Information Needs, Communication Flows, Potential Uses and Impacts of Forecast Information *(January 2007- June 2008).* The first phase was completed January 2007 and the second phase was completed in January 2009.

Task 5: Review of Environmental and Public Health Issues *(January 2007- November 2008).* Originally, this work was to be carried out in the form of two commissioned studies. Since it was not possible to find suitable host-country expertise for these tasks, information on these issues was collected during the stakeholder assessments in 2007 and 2009.
Task 6: Preliminary Design of Decision Support Tool *(January 2007 – January 2008).* In June 2007, the USA team, while there for another project, met with Host-country team members and model users including representatives of the Karfiguela plain farmers and the sugarcane farm, SUSOCO. At this meeting, a very preliminary prototype of the DST was presented. Moussa Sanon of INERA visited Tufts University on 17-19 October 2007 while on a one-year Fulbright fellowship at the University of Georgia. During that time, he reviewed the advanced design of the DST and worked with the Tufts team on the incorporation of crop modeling into the DST. In January 2008, the project PI and Derek Etkin, the Graduate Research Assistant from Tufts, participated in a workshop in Banfora with our host-country partners (INERA, DGRE and the DMN) and potential DST users to discuss in detail the proposed DST. Potential users attending represented SOSUCO, ONEA, the Karfiguela cooperative and the Chambre Regiionale d'Agriculture. The outcomes of the workshop and the meetings were that two DSTs are actually needed; 1) a less complex simulation model that users can use to develop reservoir releases using trial and error methods and sensitivity analysis of a deterministic forecast and 2) a complex multistage stochastic optimization model that uses the probabilistic forecast.
Task 7: Implementing Pilot Project *(January 2008-January 2009).* The Simulation Model was built and sent to Burkina Faso in Spring 2008 with documentation. Host-country partners did some preliminary testing and provided feedback. The stochastic optimization model was completed in December 2008. In January 2009, stakeholder workshops were held with potential users of the tools in Ouagadougou and Banfora. In the process of interacting with stakeholders, it became apparent that the available skills in Burkina Faso will only support the use of a less complex simulation model; a more complex multistage stochastic optimization model will be useful after more experience is gained with the simulation model. Therefore, the US and host-country partners decided that all the remaining efforts of the project should be devoted to enhancing the simulation model based upon host-country partners suggestions during the workshops and building capacity to use it among stakeholders. An improved tool interface and user manual are being produced and translated into French.

B. Summary of findings, including their potential or actual implications for efforts to develop applications, methods, and science-based decision support capacity/systems and to foster sustainable resource management and vulnerability reduction. *(Limit to two pages, this builds on research from previous time period)*

Water resources in the basin are subject to multiple uses and claims by stakeholders: a) a private sugar company (SOSUCO), which uses the water for sugar cane irrigation and sugar production, and which owns and manages the dams and the main distribution systems; b) the public utility company (ONEA) that provides water to the town of Banfora; c) small scale farmers downstream from the reservoirs, some of whom are organized into cooperatives such as in the Karfiguela area (Union des Coopératives des Éxploitants de la Plaine Aménagée de Karfiguela ,UCEPAK);d) riparian farmers that exploit the riverbanks and the Comoé waters for vegetable productions; e) resident and transient pastoralists whose livestock must access water for drinking; and f) fishermen who fish in the wetlands and lakes in the area. In addition, a legally mandated environmental services flow has to be released and maintained into the river ('débit sanitaire').Even during favorable rainfall years, there is not enough water to meet the needs of all water users – thus a DST based upon rainfall and precipitation forecasting will be useful. It will even more so when rainfall is below average, as it has been the case in recent years. During such times conflicts over water resources intensify.

The DST developed and proposed by this project provides a planning mechanism that promotes more efficient water resource management and a more equitable water distribution among multiple users. It

does so by enabling users to objectively represent and analyze water demands, supplies, and uses in different climatic and hydrological conditions. This allows them to develop an optimal and consensual release schedule, by reallocating water throughout the dry season and among diverse users. The tool's core variables are the amounts of water released from each reservoir and diverted to each user, particularly SOSUCO, UCEPAK, and ONEA. The DST fully models the impacts of alternative management decisions for these three main users, but also adds the needs of downstream users (riparian farmers, pastoralists, etc) into the supply of water released for minimum ecological flow requirement.

The DST is envisioned to be operated in a consultative setting, ideally in the context of the government-organized local water management committee (Comités Locaux de l'Eau, CLE) meetings, and therefore much effort has been devoted to making it relatively easy to understand and operate even by users without strong background in modeling, engineering, statistics, or computer technology. In line with the nation's decentralized integrated water resources management strategy mandate and the CLE's inclusive scope, the project shifted its DST design from a prescriptive to an experimental approach, moving from a more complex stochastic, multi-stage, linear programming optimization model (which requires a higher level of expertise of operate) to a simpler simulation tool that allows lay users to learn hands-on and to adjust their decisions by trial and error. The latter's simplicity promotes greater transparency, an important feature in consultative negotiations, particularly where there are substantial differences in technical ability and a history of mistrust and resentment among users. Furthermore, by virtue of its greater flexibility, the simulation tool makes it possible for users to consider and propose modifications to the status quo. For example while the tool's starting configuration establishes the given order of priority in reservoir releases (from Lobi, to Moussoudougou, to Toussiana) and in user diversions (starting with ONEA, then SOSUCO, then UCEPAK, to end with the downstream users' needs and minimum ecological flow requirement), the sequence can be manually rearranged by users. Its more intuitive, user-friendly interface enables less experienced users to acquire capacity and confidence in applying DSTs to water resource management planning.

Some measure of the potential value of the tool is that the Millennium Challenge Corporation contacted the project in Fall 2007 about its use in the Comoe River Basin to help in planning some expansion of the irrigation. The expansion planning was never undertaken because they realized the basin is already short of water.

C. List of any reports, papers, publications or presentations arising from this project; please send any reprints of journal articles as they appear in the literature. Indicate whether a paper is formally reviewed and published. *(No text limit)*

Sanon, M., Roncoli, M.C., Kirshen, P., Somé, L., Sanfo, J., Zoungrana, J., and Hoogenboom, G., Involving Multiple Users in the Participatory Development of Water Resources Management Tools in the Comoé River Basin, Burkina Faso, abstract submitted to AGRHYMET workshop on Information Sharing with Farmers, Niamey, Niger, 2009.

Roncoli, C., Kirshen, P., Etkin, D., Sanon, M., Somé, L., Sanfo, J., Zoungrana, J., Hoogenboom, G., Managing Water or Mediating Among Users: Introducing Decision Support Tools in a Multi-User Context in Burkina Faso, accepted with revisions, Environmental Management, 2009.

Sanon, M., Roncoli, C., Hoogenboom, G., Kirshen, P., Some, L., Sanfo, J., Jost, C., Communicating Climate Forecasts to Rural Producers: Perspectives from Participatory Research, Invited paper presented at a workshop on Adaptation to Climate Change: Strengthening Capacities in Africa, German Development Institute and Stockholm Environment Institute, Bonn, Germany, November 26.-27, 2008.

Kirshen, P., Roncoli, C., Hoogenboom G., Etkin, D., Some, L., Sanon, M., Sanfo, J., and Zoungrana, J., Use of Seasonal Forecasting as a Climate Change Adaptation Tool for the Sahel-Sudan, West Africa, invited presentation at UNDP, New York, NY, November 18, 2008.

Etkin, D., Kirshen, P., Watkins, W., Diallo, A.A., Hoogenboom, G., Roncoli, M.C., Sanfo, J., Sanon, M., Somé,L., and Zoungrana, J., Risk Based Decision Support for Reservoir Scheduling in West Africa, Proceedings ASCE World Environmental and Water Resources Congress, Honolulu, Hawaii, 13-16 May 2008.

Roncoli, C., Kirshen, P., Hoogenboom G., Some, L., Sanon, M., Sanfo, J., and Zoungrana, J., Managing Water or Mediating among Users: Introducing Climate-Based Decision Support Tools in A Multi-Stakeholder Context in Southwest Burkina Faso, paper presented at the Society for Applied Anthropology Annual Meeting, Memphis, Tennessee, March 25-29, 2008.

D. Discussion of any significant deviations from proposed workplan (e.g., shift in priorities following consultation with program manager, delayed fieldwork due to late arrival of funds, obstacles encountered during the course of the project that have impacted outcome delivery). *(Limit to one paragraph)*

We have applied for a one year no cost extension because we could not start field research until January 2007 to accommodate the schedule of our host-country partners and to time fieldwork at a time when farmers and other users are less busy. After the project started, we realized that more time was needed to collect the necessary data and complete the research. The extension enabled the research team to closely integrate efforts and monitor impacts within an emerging national policy framework that promotes decentralized integrated water resource management. We expect that the tool will play a key role in these multi-user negotiations and planning

Professor Christine Jost of Tufts University and expert in pastoralism and participatory methodologies resigned from Tufts University in Fall 2007 to take a new position with one of the CGIAR research centers. Dr. M C Roncoli has taken over her research tasks.

E. Where appropriate, describe the climate information products and forecasts considered in your project (both NOAA and non-NOAA); identify any specific feedback on the NOAA products that might be helpful for improvement. (bulleted response)

The region could benefit from more comprehensive, probabilistic forecasts, eg 10 day precipitation during the year.

III. GRAPHICS: PLEASE INCLUDE THE FOLLOWING GRAPHICS AS ATTACHMENTS TO YOUR REPORT

A. One Power point slide depicting the overall project framework/approach/results to date (included)

B. If appropriate, additional graphic(s) or presentation(s) depicting any key research results thus far (provided at completion). System schematic, simulation tool schematic, regional map, and study site map are attached.

C. Photographs (if easy to obtain) from fieldwork to depict study information (if applicable) (provided at completion). A CD is being prepared and will be sent.

IV. WEBSITE ADDRESS FOR FURTHER INFORMATION (IF APPLICABLE)

none

V. ADDITIONAL RELEVANT INFORMATION NOT COVERED UNDER THE ABOVE CATEGORIES.

none